

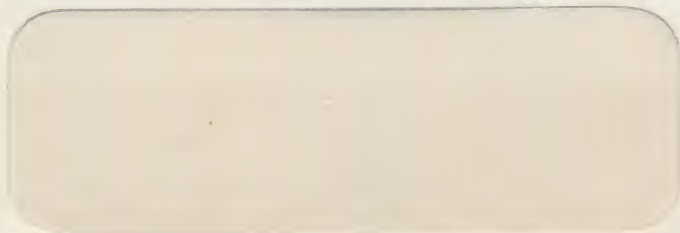
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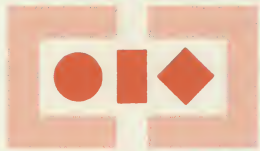
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March, 1967

Dear Member:

Popular opinion to the contrary, computers are not "magical machines" or "giant brains." Actually high-speed, reliable "idiots", they must be carefully instructed in every step of their computation. The only insight they have into the problems they are solving must be codified by the human mind into a form recognizable by the computer.

These limitations have meant that all information received, stored, and processed by a computer must be expressed in the form of a symbolic code, or "machine language." In many computer applications, artificial languages (FORTRAN, COBOL, ALGOL, etc.) have been formulated by logicians or mathematicians, and their programs can be indeed formidable. (The IBM 704 FORTRAN, for example, consists of some 24,000 machine instructions and required the equivalent of 18 man-years to develop.)

However, because computers can manipulate any symbols representable by binary numbers, there is another and highly important code or language that can be processed by a computer: a natural language--made up of alphabetic symbols--such as English (or Russian or Swahili).

This month's Main Selection

NATURAL LANGUAGE AND THE COMPUTER

Edited by Paul L. Garvin

is an authoritative overview of the emerging field of language-data processing. Fourteen of the country's leading experts in the area of the natural-language applications of computers explore this important new field in the seventeen comprehensive chapters that make up this timely volume.

The editor, Paul L. Garvin of The Bunker-Ramo Corporation, has divided the contributions into six parts which mirror the logical structure of the field.

Part One of **NATURAL LANGUAGE AND THE COMPUTER** describes the approaches devised by professional linguists to conceptualize and analyze natural languages for the purposes of computer use. One of the tasks of linguistic science is to construct a model which will generate sentences which characterize the qualities of a given natural language. For example, there is the problem of accepting as grammatical or rejecting as ungrammatical any sentence, quite apart from whether it is "sensible" or not. (Consider the nonsensical but grammatical utterance: "Purple cows usually smoke blue and white bananas.")

(continued on back page)

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This month's Main Selection is the first book to provide a comprehensive survey of the emerging field of language data processing (by "language" is meant a natural language such as English or Russian, and not an artificial language such as the languages devised by mathematicians or logicians). It not only covers all aspects of the computer processing of natural language-data, but also gives extensive background material in linguistics, mathematics and computation.

NATURAL LANGUAGE AND THE COMPUTER

Edited by Paul L. Garvin

*a collection of seventeen papers by leading
mathematicians, logicians, linguists and
experts in computer science*

These papers offer a cross section of opinions and approaches representing the major pioneering trends in this exciting new area of computer application. They are grouped in six parts in the book, intended to represent the logical structure of the field.

First, in order to deal with natural language efficiently, one must know something about its properties. Hence, Part I deals with approaches devised by professional linguists to conceptualize and analyze natural languages. Next, Part II covers mathematics and the computer, the various computer "languages" and how they differ from natural language, and programming for natural language.

Part III attempts to relate the properties of natural languages to the problem of processing data on a computer—from a linguistic, a logical, and a mathematical standpoint. Then Parts IV and V deal with the two areas of language data processing which, at the present time, have shown the most tangible results: machine translation and information retrieval.

Finally, Part VI provides an evaluative overview of this entire new field of language-data processing.

Written in a manner intelligible to non-specialists, NATURAL LANGUAGE AND THE COMPUTER should prove of inestimable value to persons interested in this exciting new area of computer application.

Examine this complete list of articles and contributors:

PART I—Three Linguistic Models of Language

- The Definitional Model of Language.
Paul L. Garvin, Member, Senior Staff, The Bunker-Ramo Corporation, Canoga Park, California
- The Transformational Model of Generative or Predictive Grammar.
Robert P. Stockwell, Professor of English, University of California, Los Angeles, California
- The Informational Model of Language: Analog and Digital Coding in Animal and Human Communication.
Thomas A. Sebeok, Chairman, Indiana University Research Center in Anthropology, Folklore and Linguistics, Bloomington, Indiana

PART II—Mathematics and Computation

- The Use of Mathematics in the Behavioral Sciences.
W. Karush, Principal Scientist, System Development Corporation, Santa Monica, California
- Computer Languages.
Michel A. Melkanoff, Associate Professor of Engineering, University of California, Los Angeles, California
- Programming for Natural Language.
L. C. Ray, Chairman, Special Interest Group on Informational Retrieval of the Association for Computing Machinery, Santa Monica, California

PART III—Language-Data Processing

- A Linguist's View of Language-data Processing.
Paul L. Garvin
- A Logician's View of Language-data Processing.
M. E. Maron, Member, Senior Research Staff, The RAND Corporation, Santa Monica, California
- A Statistician's view of Linguistic Models and Language-data Processing.
E. P. Edmundson, Member, Senior Staff, The Bunker-Ramo Corporation, Canoga Park, California
- Research Procedures in Machine Translation
David G. Hays, Project Leader, Linguistic Research Projects, The RAND Corporation, Santa Monica, California

PART IV—Machine Translation

- Dictionary Problems in Machine Translation.
Kenneth E. Harper, Consultant, The RAND Corporation, and Associate Professor of Slavic Languages and Literatures, University of California, Los Angeles, California

- Syntax in Machine Translation.
Paul L. Garvin
- Programming Aspects of Machine Translation.
Jules Mersel, Member, Senior Staff, The Bunker-Ramo Corporation, Canoga Park, California

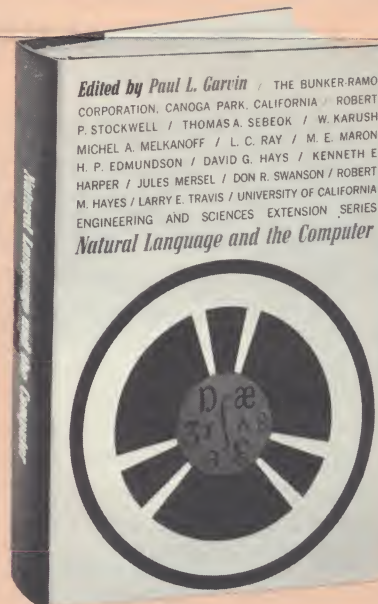
PART V—Information Retrieval

- The Formulation of the Retrieval Problem.
Don R. Swanson, Dean, Graduate Library School, University of Chicago, Illinois
- Mathematical Models in Information Retrieval.
Robert M. Hayes, Division Manager, Advanced Information Systems Division, Hughes Dynamics, Inc., Los Angeles, California
- Analytic Information Retrieval.
Larry E. Travis, Member, Artificial Intelligence Research Staff, System Development Corporation, Santa Monica, California

PART VI—Overview

- Linguistics, Data Processing, and Mathematics.
Paul L. Garvin and W. Karush

Main Selection



NATURAL LANGUAGE AND THE COMPUTER

Edited by Paul L. Garvin

398 pages

Publisher's price \$12.75

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And what can a computer make of the grammatical ambiguity of the sentence: "They ordered the police to stop drinking after midnight."?

In Part Two, the interaction of mathematics and computation is explored as a foundation for the four insightful parts that comprise the remainder of this book. (It is interesting to note that recent research has indicated that the human brain and nervous system have characteristics of both a digital and an analog computer.)

Part Three relates the properties of natural languages to the entire problem of computerized data-processing from the viewpoint of the linguist (Paul L. Garvin), the logician (M.E. Maron), and the statistician (H.P. Edmundson).

The fourth part of **NATURAL LANGUAGE AND THE COMPUTER** lucidly explores that area of language-data processing which has received the widest attention: the machine translation (MT) of the content of an expression in one language (the source language) into the same content in another language (the target language).

Paul L. Garvin's contribution, "Syntax in Machine Translation," deserves special mention for the clarity of its description of the ingenious "fulcrum technique for syntactic analysis." (This technique is based on a search for the fulcra of a sentence: those words which give the most information about the other words in a given sentence. In Russian, the fulcrum of a sentence is always the predicate because it gives information about possible subjects and objects.)

No presentation of natural languages and data processing would be complete without a discussion of still another exciting area that has yielded very tangible results: information retrieval. The basic problems of information retrieval have been described paradoxically as "often solved but never formulated." The contributors to Part Five of **NATURAL LANGUAGE AND THE COMPUTER**, Don R. Swanson, Robert M. Hayes, and Larry E. Travis, go a long way toward stating as well as solving the fundamental problems of information retrieval. Their articles offer penetrating insights into this challenging area.

NATURAL LANGUAGE AND THE COMPUTER is a masterful exploration of how the two disciplines of linguistics and mathematics can be joined to expand our knowledge of the potentialities of the computer. No one who is concerned with information processing in any of its many-faceted aspects can afford to miss this important and timely volume.

Sincerely yours,

Martin Reynolds

Martin Reynolds
Executive Director

Alternate Selection

Richard Bellman on

Adaptive Control Processes

Here is a comprehensive overview of the modern field of automatic control theory and its mathematical foundations, by one of today's most brilliant mathematicians. In essence, the book furnishes a simple and novel technique for making problems involving decision processes amenable to solution through *dynamic programming* (defined by author Bellman as "a mathematical theory designed to study the formulation, analysis, and computational treatment of multistage decision processes").

More specifically, the book treats *dynamic programming of the adaptive type*, whereby an initial lack of information is overcome by observation and experimentation as the process continues.

If the subject of ADAPTIVE CONTROL PROCESSES is the basic aspects of control theory, its main theme is that *dynamic programming* is a conceptually simple, computationally feasible, almost universally applicable method for dealing with the problems of optimization (under many constraints) arising in control processes. In relation to *dynamic programming*, such diverse topics as theory of games and pursuit processes, Markov processes, stochastic learning models, sequential machines, communication theory, and successive approximation are treated in illuminating fashion.

The utility of Bellman's approach is enormous and wide ranging: workers in communications or forecasting; statisticians refining decision theory; operations research and systems analysts—there is almost no area of computer or information science in which dynamic programming will not find application. It is equally of interest to the pure or applied mathematician, or to the engineer confronted in any field by control problems that cannot be handled by conventional methods.

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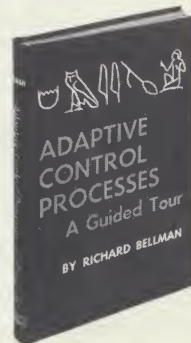
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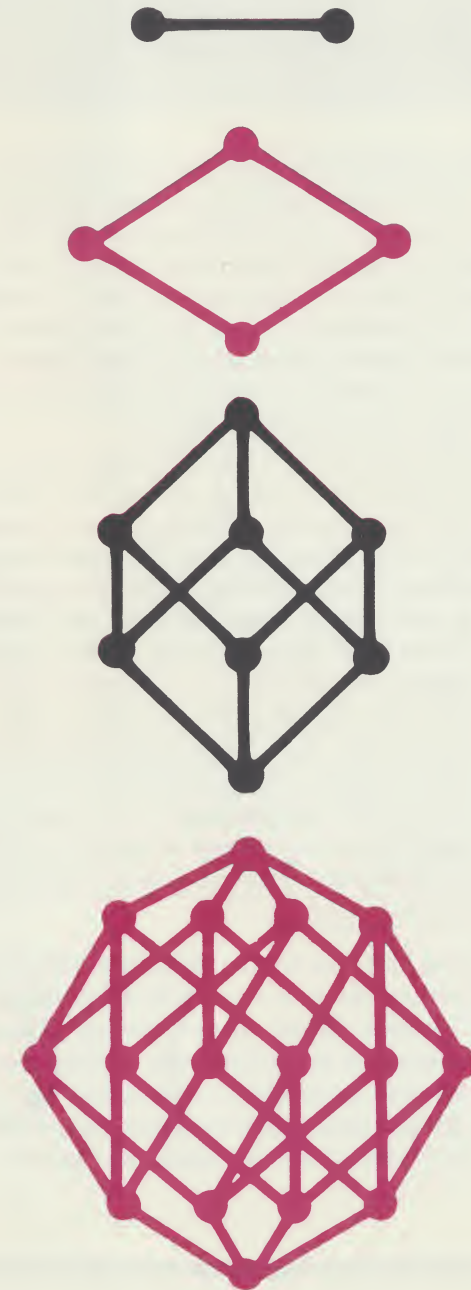
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Alternate Selection



Logic and Boolean Algebra

"Abstractness, sometimes hurled as a reproach at mathematics"—noted the great mathematical historian Eric Bell—"is its chief glory and its surest title to practical usefulness."

Of all the domains of mathematics, perhaps one of the most convincing examples of the ultimate utility and practical application of highly abstract concepts is the evolution of *algebra*. The "pure" line of algebraic thought, as it became increasingly abstract, can be traced from the formalization of elementary algebra in the 1830's and the work of Galois in the theory of equations, through the development of linear algebra, to the creation of mathematical logic by George Boole in 1847-1854. Today, the essence of Boole's "calculus of deductive reasoning" forms the basis for the logic of the modern computer.

In 1854, with the publication of his *Laws of Thought*, Boole—without quite realizing his achievement—had taken the first critical step towards the abstract algebras of the 20th century. Though we can no longer completely accept the notion, early promulgated by Bertrand Russell, that formal logic *is* pure mathematics—the Boolean algebra of classes has had an enormous impact on some of the most important and fundamental mathematical thought of our time. Indeed, it gave the first substance to Leibniz' dream of a "calculus of reasoning", a "universal mathematics".

Since World War I, the most significant development in Boolean algebras have been their incorporation into the modern algebraic structure of rings, groups and ideals, and the elaboration in the U.S.—by Stone, Bernstein and von Neumann—of Boole's foundation in contemporary form.

It is to this most highly developed version of Boolean algebra that B. H. Arnold addresses himself—with rare but typical clarity and cohesiveness—in **LOGIC AND BOOLEAN ALGEBRA**.

Throughout the volume Professor Arnold concentrates on the *structure* of Boolean algebras and Boolean rings as it is developed through simpler algebraic systems. Based on this abstract approach, the author—Professor of Mathematics at the University of Oregon—starts his discussion with a superbly clear presentation of elementary logic from an *intuitive* point of view. He next proceeds to the operational starting point of Boolean logic—the basic *ordered set*—and moves on through a succes-

sion of algebraic systems leading the reader to the fascinating realm of *lattice theory* and a detailed treatment of the structural essentials of Boolean algebras. Taking full advantage of the brilliant work of contemporary mathematicians such as Birkhoff, who have given Boolean systems such a high degree of sophistication, **LOGIC AND BOOLEAN ALGEBRA** is liberally sprinkled with illuminating examples taken from related areas of logic and set theory.

The core of the discussion is met in chapters 5 and 6 of **LOGIC AND BOOLEAN ALGEBRA**. Here, the author defines the structure of a Boolean system as a *complemented, distributive lattice*. Constantly utilizing the concepts and symbols of set theory, he also introduces a key theorem showing that every finite Boolean algebra can be represented by the collection of all subsets of some set. After demonstrating how such a specific structure can satisfy the criteria for a Boolean algebra, Arnold illustrates precisely its application to mathematical logic and then explores the identity of Boolean rings with Boolean algebras. In each chapter, Professor Arnold provides the reader with a delightful variety of unusually useful and instructive problems that range from the truth value of propositions to "designing" a simple network for adding integers using binary notation.

The last portion of the volume deals with the fascinating manner in which Boole's work has become a vital factor in the design of electronic circuitry for the high-speed digital computer. Binary representations are, of course, the basis of the computational operations of digital data processors. Boole's contribution is that his algebraic system provides a method—a set of rules—for combining and manipulating binary signals. Using simple, two-circuit networks as his models, Professor Arnold presents a concise introduction to the "logic" of electrical network and circuit analysis.

In this way, **LOGIC AND BOOLEAN ALGEBRA** reflects the total essence of George Boole's extraordinary achievement—from the birth of mathematical logic to the breath-taking capabilities of electronic brains.

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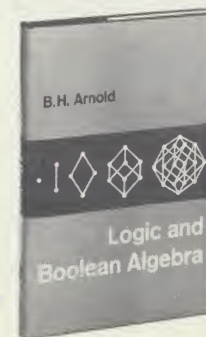
Logic and Boolean Algebra

by B. H. Arnold

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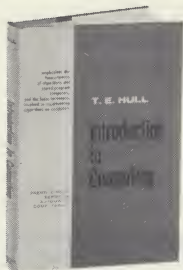
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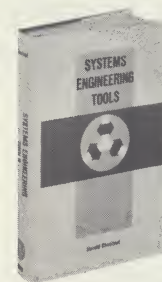
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